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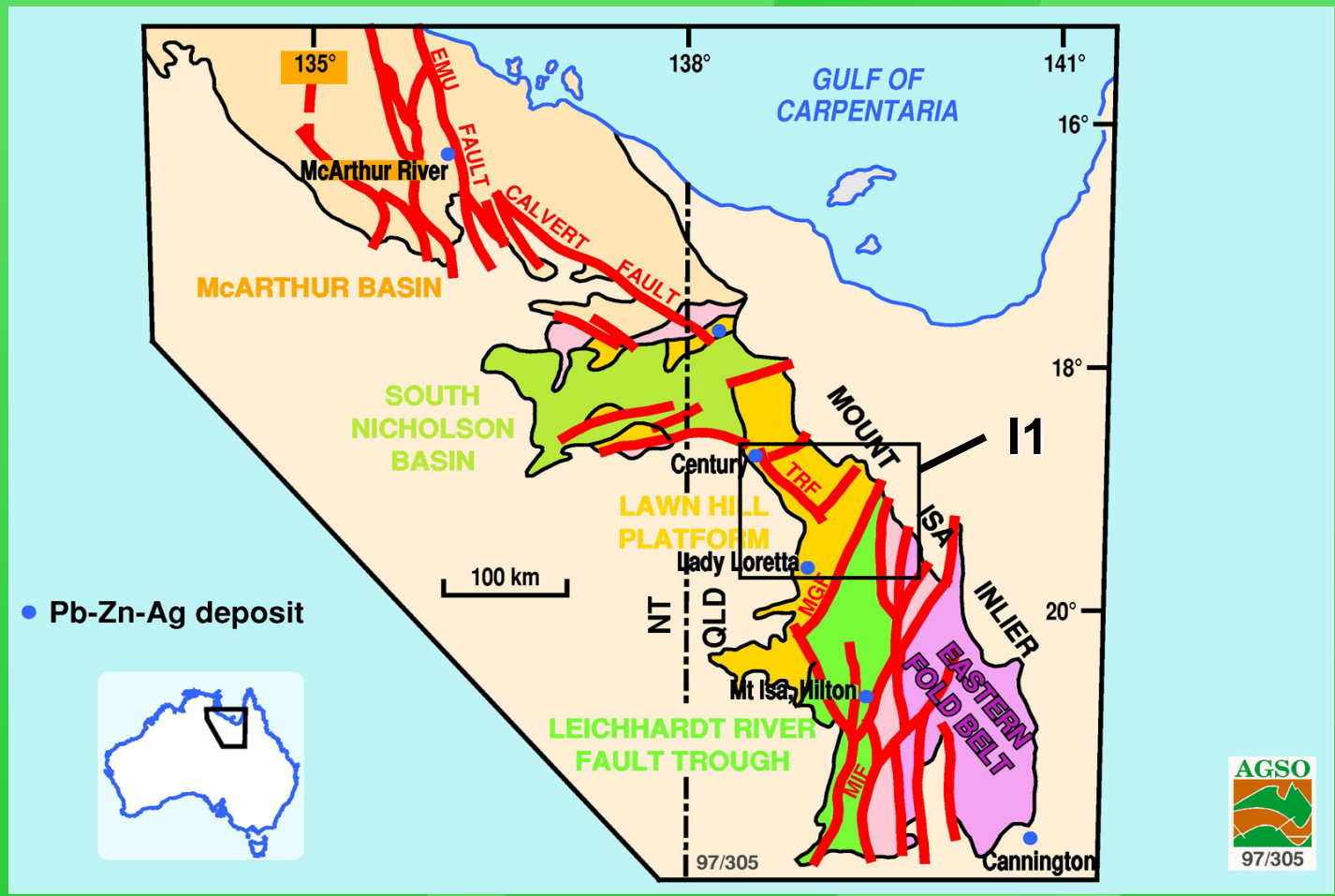
Mount Isa Pb-Zn-Ag Mineral Province

Project elements:

- Termite Ra Fault
- Mt Gordon Fault
- Lawn Hill Platform meets Leichhardt River Fault Trough
- Change in rift orientation



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Western Succession 3D basin architecture & ore systems

Overview:

- 15 months into project
- 3 new shared staff appointments
  - Structural geology & economic geology (Sept. 02)
  - Geophysics (July 03)
- State Government involvement through Qld NRM
- Expanded research capacity through GA graduate recruitment program –sequence stratigraphy (3); zircon geochronology (1)
- Training provided into GA recruitment program

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Needs of Exploration Industry

Basin architecture at time of fertile fluid generation & migration

- Nature & distribution of source rocks (origin of fertile fluids)
- Fluid conduits & pathways
- Mineralisation traps

Timing of Mineralisation (Linkage to F3)

- fluid development & migration
- Entrapment
- Relationship to potassic-hematite alteration
- Pb-Zn versus Cu

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Western Succession 3D basin architecture & ore systems

1. Serial cross-sections & 3D architecture (GOCAD)
2. Kinematic history of key structures/faults/shears
3. Upward continued wavelet analysis (aeromag.)
4. Sequence stratigraphy (depocentres;boundaries)
5. PIMA & Hyperspectral analysis
6. Metamorphism & P-T conditions
7. Gap analysis & deposit database
8. Zircon provenance studies & timing of key events

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Building the 3D Model

Integrating:

- Lithostratigraphic and/or chronostratigraphic (sequence) boundaries & unconformities
- Thickness variation in sedimentary packages
- Geometry of bounding structures & faults
- Basin topography (erosion vs non-deposition)

Deconstructing:

- Post-depositional structures (folds, faults)
- Tectonic excision vs structural repetition

Integration & testing of previous research

NW Queensland Mineral Province report

- Rift basin: 13 tectonic events (1800 Ma → Isa D3 event)
- Initial NE-SW rifting (ECV + Myally Gp.)
- Episodic NW-SE extension (Quilalar thro' McNamara time)

Monash University Rift Model

- Initial E-W (or SW-NE) trending half-graben; bounded by transfer faults (cf NW-SE half-graben favoured by NABRE)

NABRE (P552) Sequence Stratigraphy

- Strike-slip basins - convergent margin (NW-SE thickening wedge)
- Post-Quilalar (Myally) age for NE-SW half-graben

Thrust Model (Bell, 1983)

- N over S directed thrusting & duplex development

Mineral System (NABRE)

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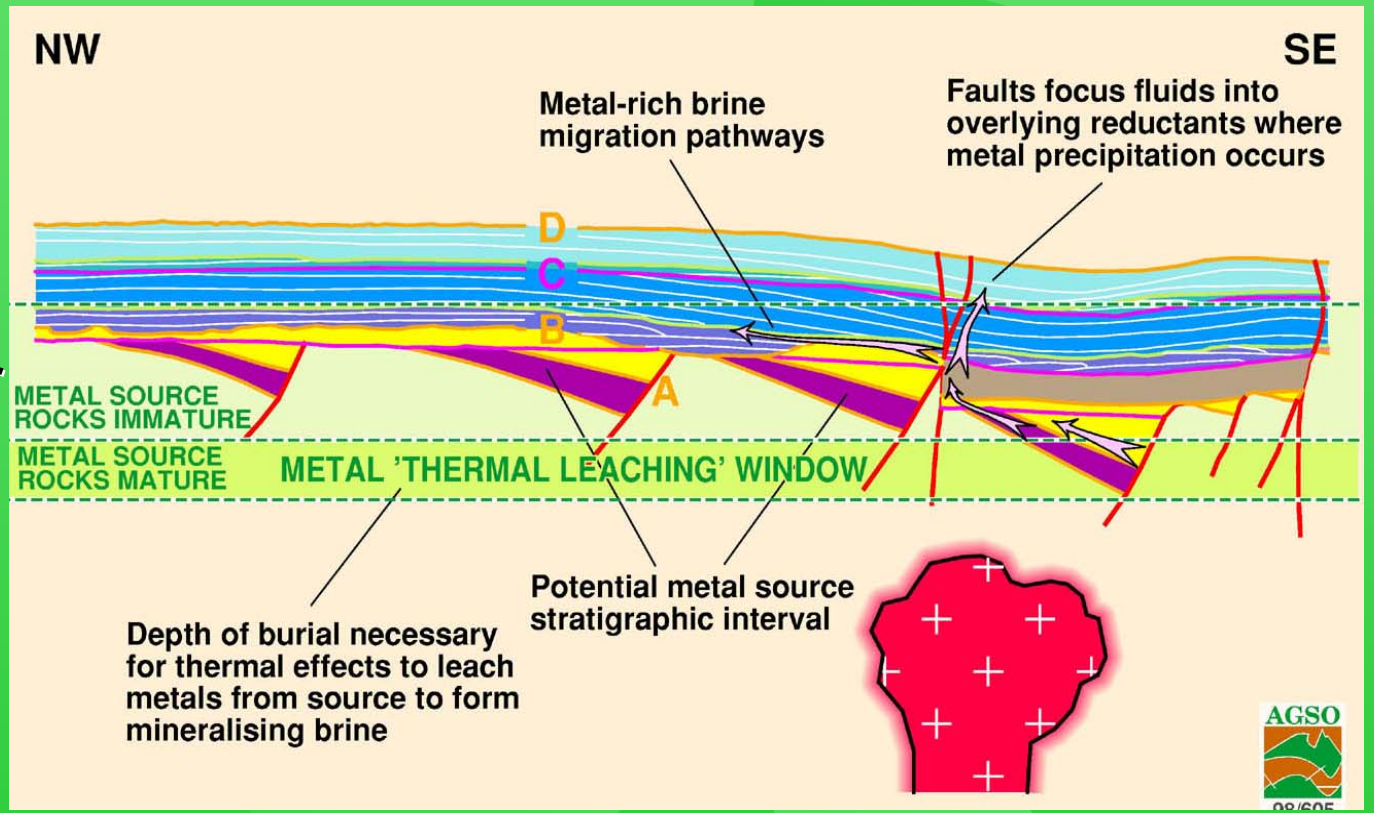
Assumptions:

- **Sequence thickness governed solely by depositional or erosional processes**
- **Little or no structural thinning or excision**
- **No thrust repetition**



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Geology for GOCAD

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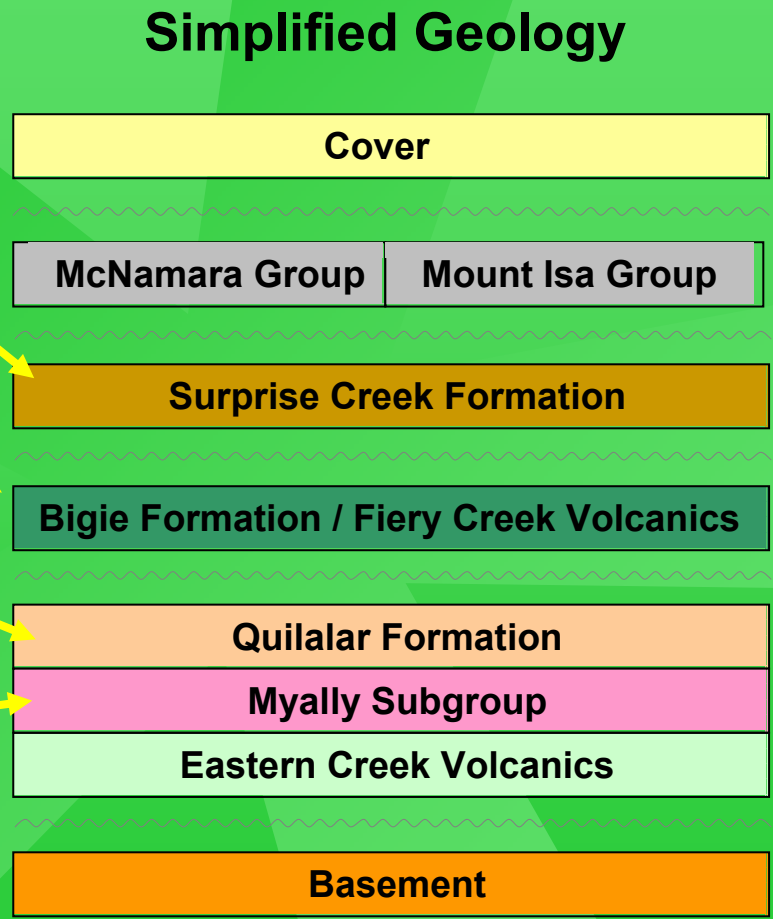
Marginal (qzite) → shallow marine (carbonate)

Fluviatile (conglom; red beds)

Marginal (qzite) → shallow marine (carbonate)

Fluviatile (qzite + sste) → marginal marine (sste + siltste)→ red beds (sste)



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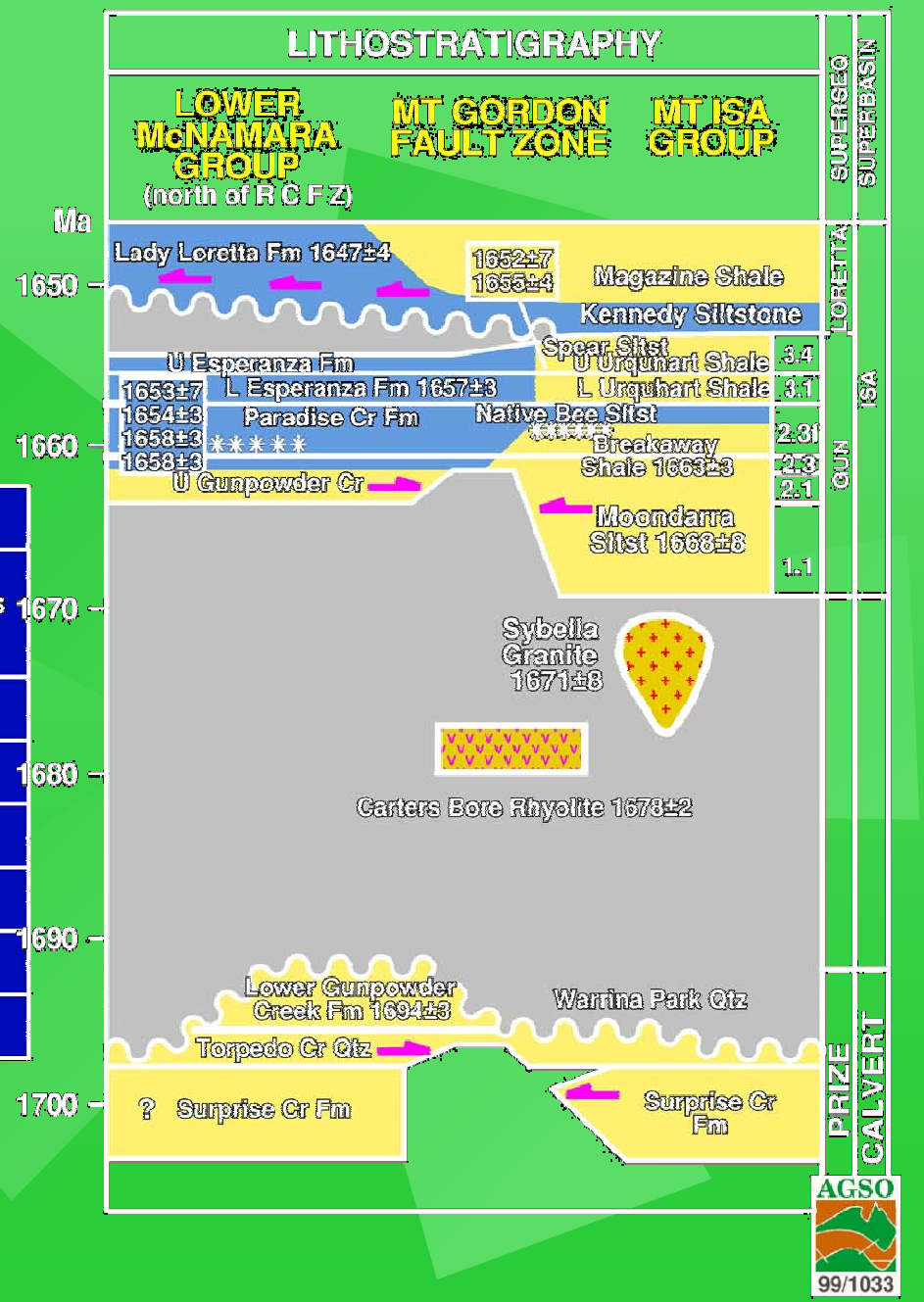
Critical surfaces for GOCAD?:

(1) Chronostratigraphic
(2) Lithostratigraphic
(3) Structural

Lower McNamara Group	Mount Isa Group
Lady Loretta Fm	?——?——?
?——?——?	Magazine Shale
Esperanza Fm	Spear & Kennedy Siltstones
?——?——?	Urquhart Shale
Paradise CreekFormation	
***	***Native Bee Siltstone
Mount Oxide Chert Marker	Breakaway Chert Marker
Gunpowder Creek Fm	Breakaway Shale
	Moondarra Siltstone
Torpedo Creek Quartzite	Warrina Park Quartzite
Surprise Creek Fm	

(After Derrick & Sweet 1980)

* *Unnamed chert member (mid stromatolite marker bed)*



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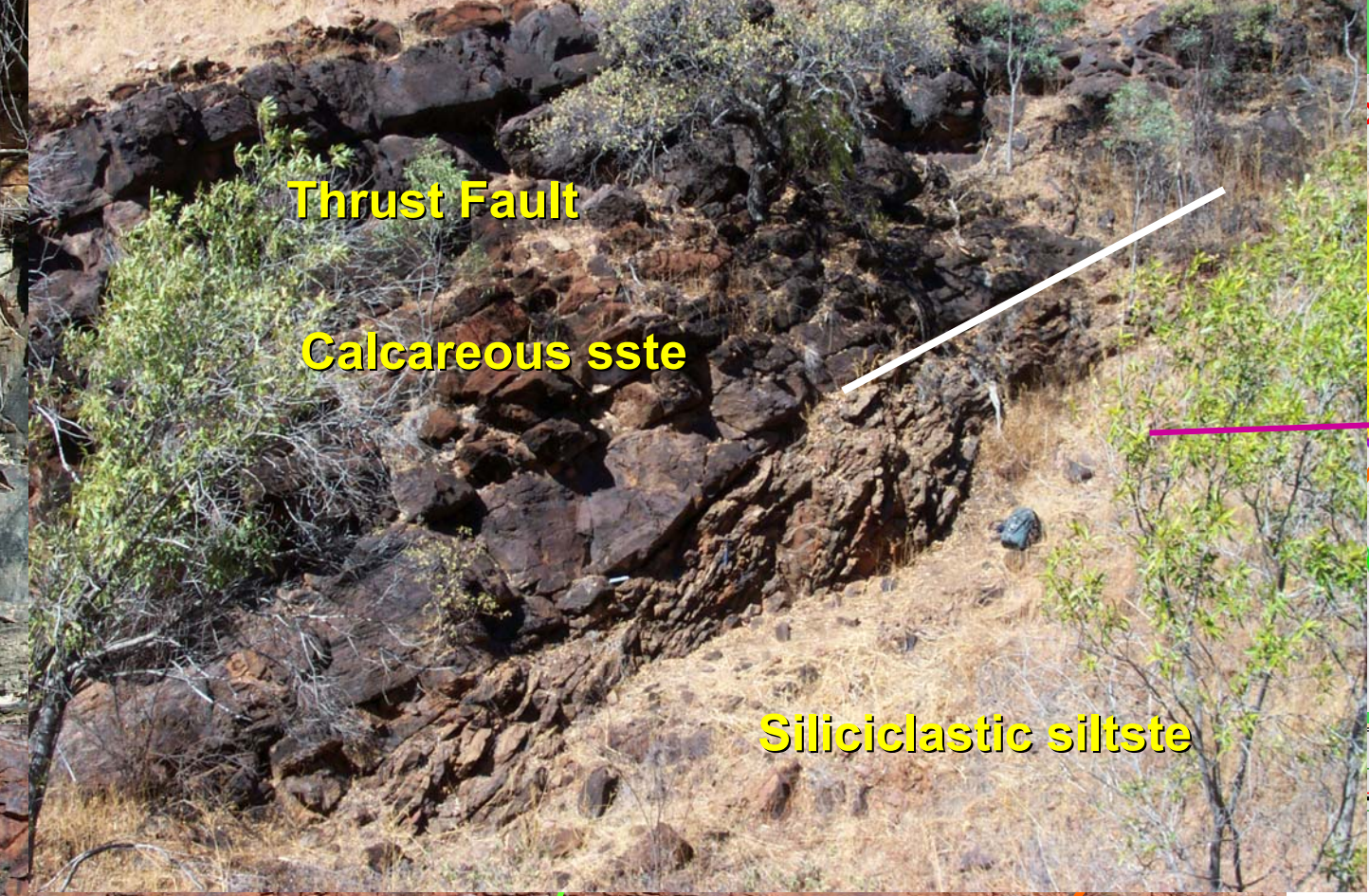
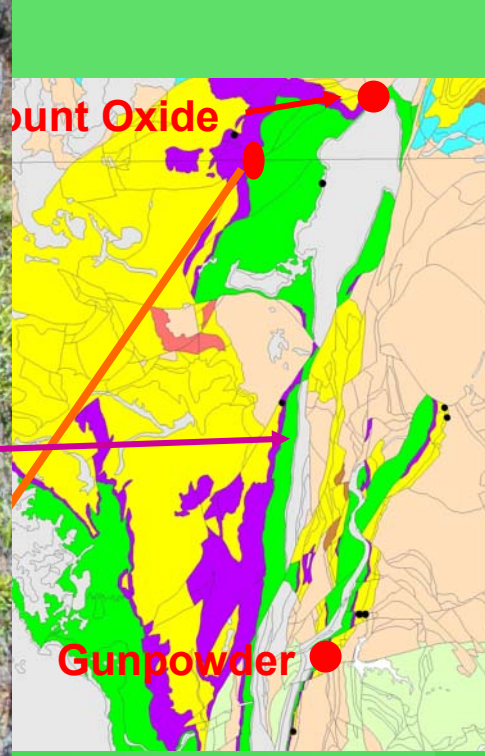
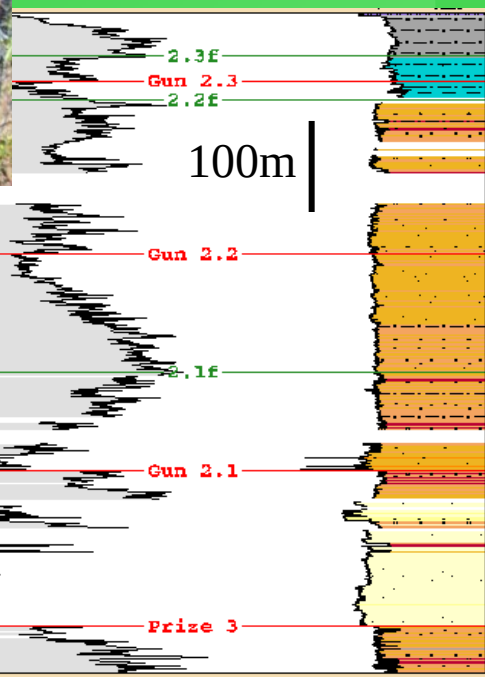
AGSO
99/1033


Thrust Fault
Calcareous sste
Siliciclastic siltste


ount Oxide
Gunpowder


2.3f
Gun 2.3
2.2f
100m
Gun 2.2
Gun 2.1
Prize 3

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Hyperspectral imagery as aid to surface recognition, major structures & mapping of alteration patterns (fluid conduits):

- **ECV vs sedimentary units**
- **Tapering wedge geometries**
- **Truncations & discontinuities (U/C; faults; shear zones)**
- **Folds**

Landsat Band 157; red (clays); green (Fe-oxide); blue (SiO2)

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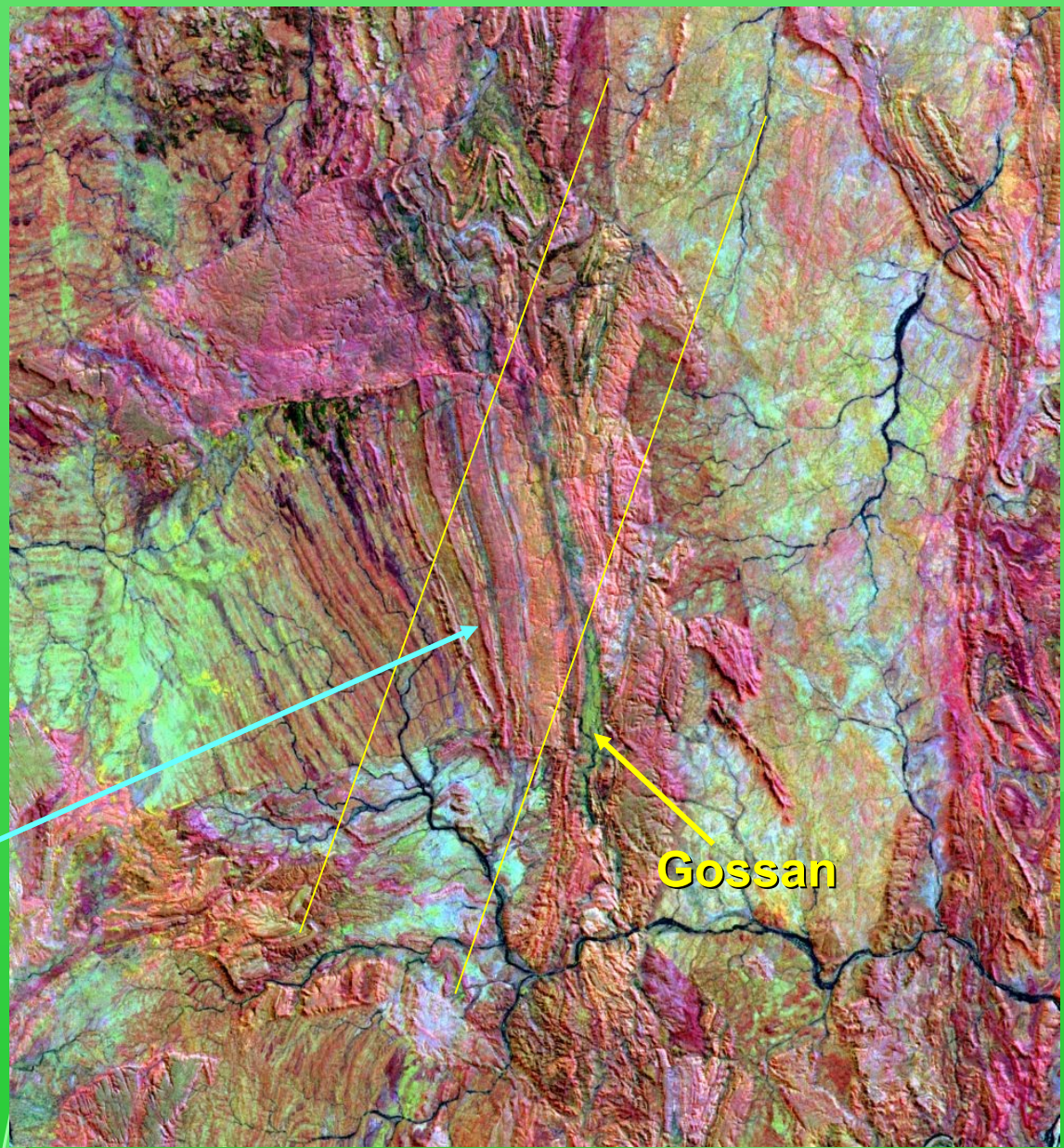
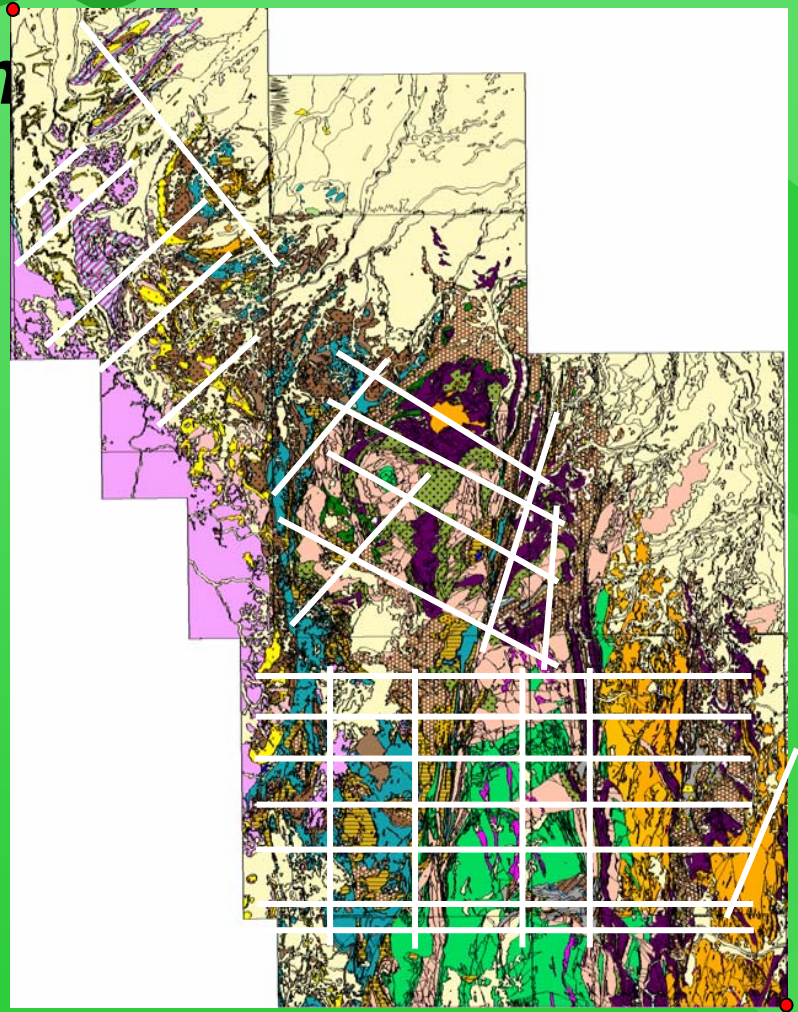
Landsat image processed to enhance resolution of clay (red), iron oxide (green) and silica-rich (blue) units

7 km-wide swathe to be sampled by Hyperion



predictive mineral discovery

138°30, 18°22



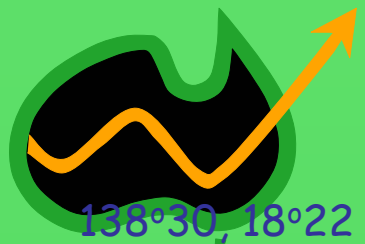
I1 Project Area, displaying solid geology and locations of current cross-sections

140°, 20°10

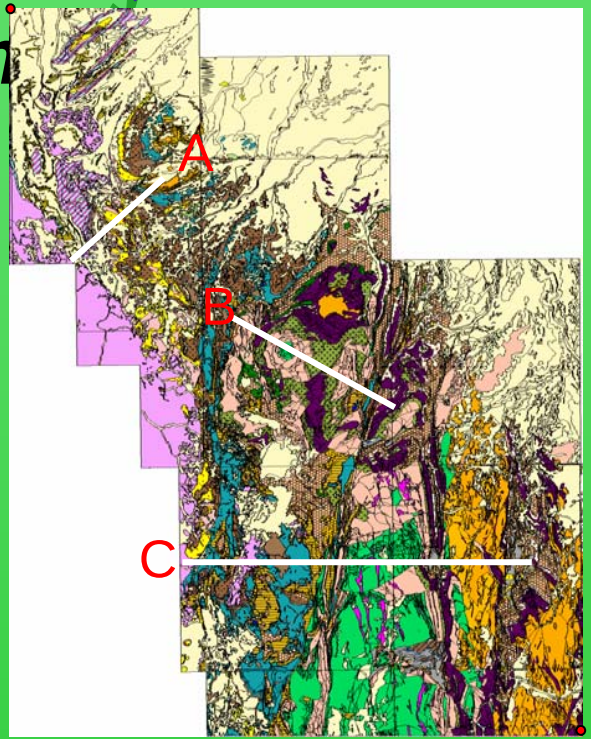
Structural Analysis

Serial Cross-sections through:

- **Termite Ra. Fault (SW-SE sections)**
- **Fiery Creek Dome**
- **Mt Gordon Fault Zone**
- **Haslingden Group (half-graben geometry in southern part of area)**
- **Cover/basement relations east of Lake Julias**

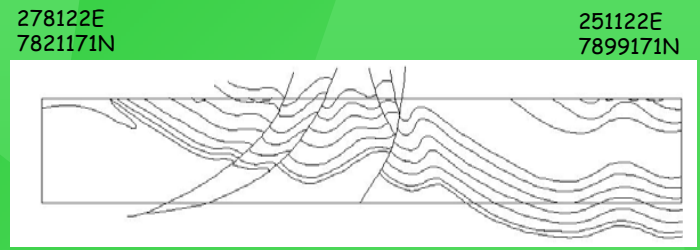


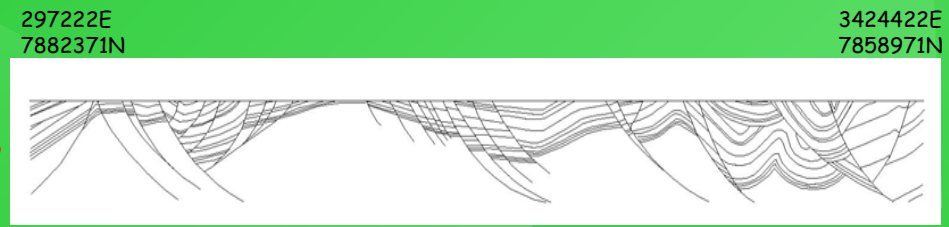
138°30, 18°22

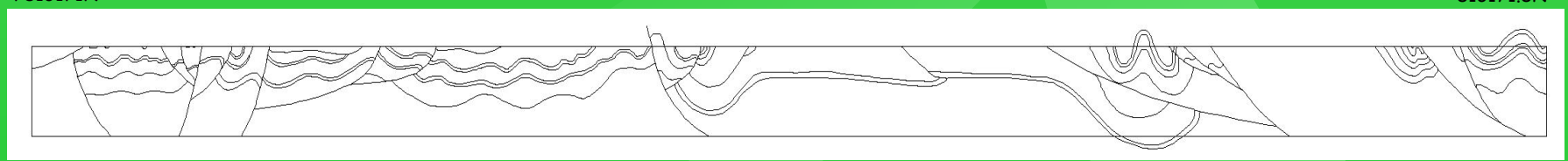


140°, 20°10

- 3D structural geometry constrained by spatially referenced surfaces from cross- sections and solid geology
- Original extensional geometry modified by E-W shortening & thrusting







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Potential field modelling

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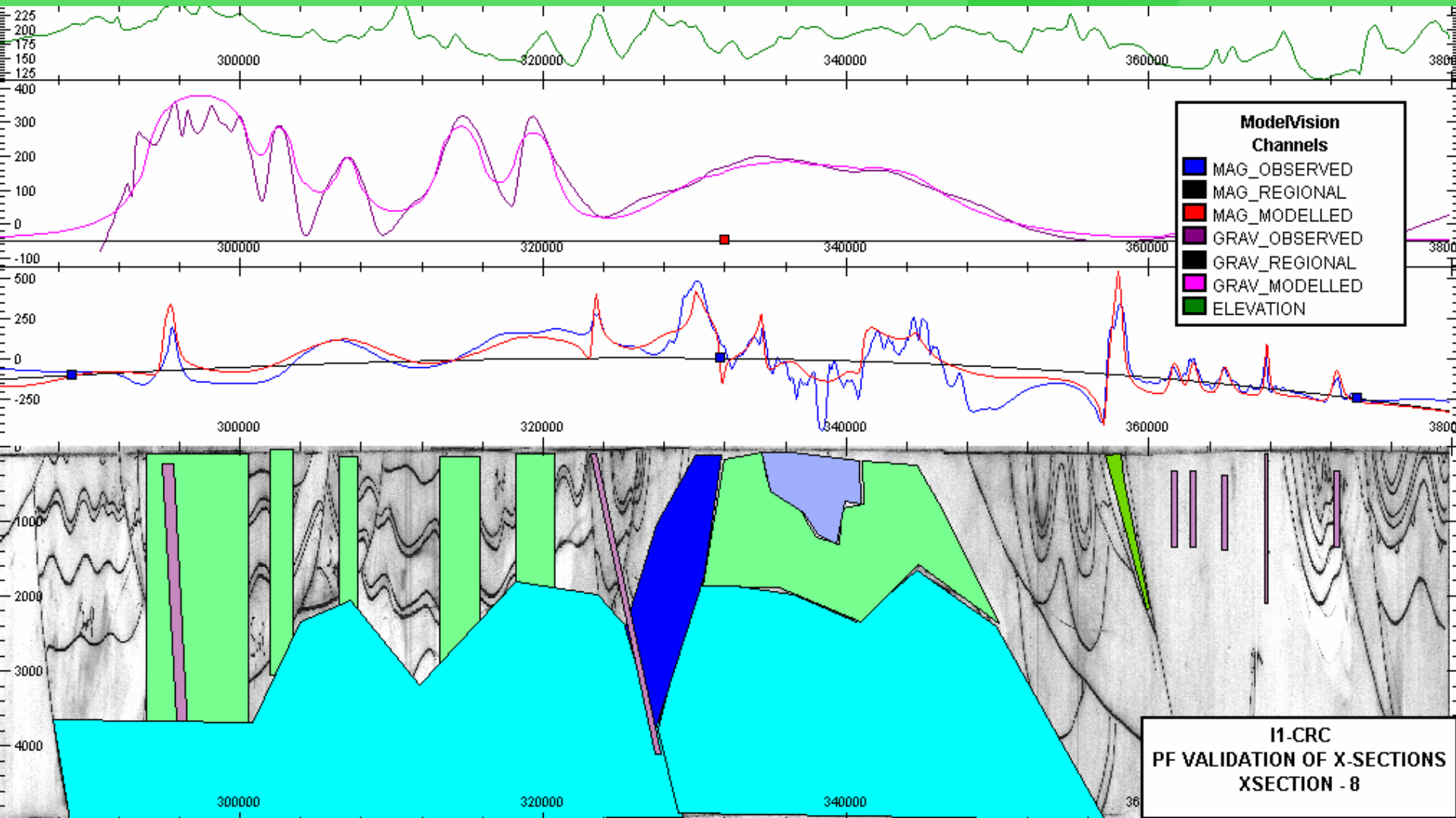

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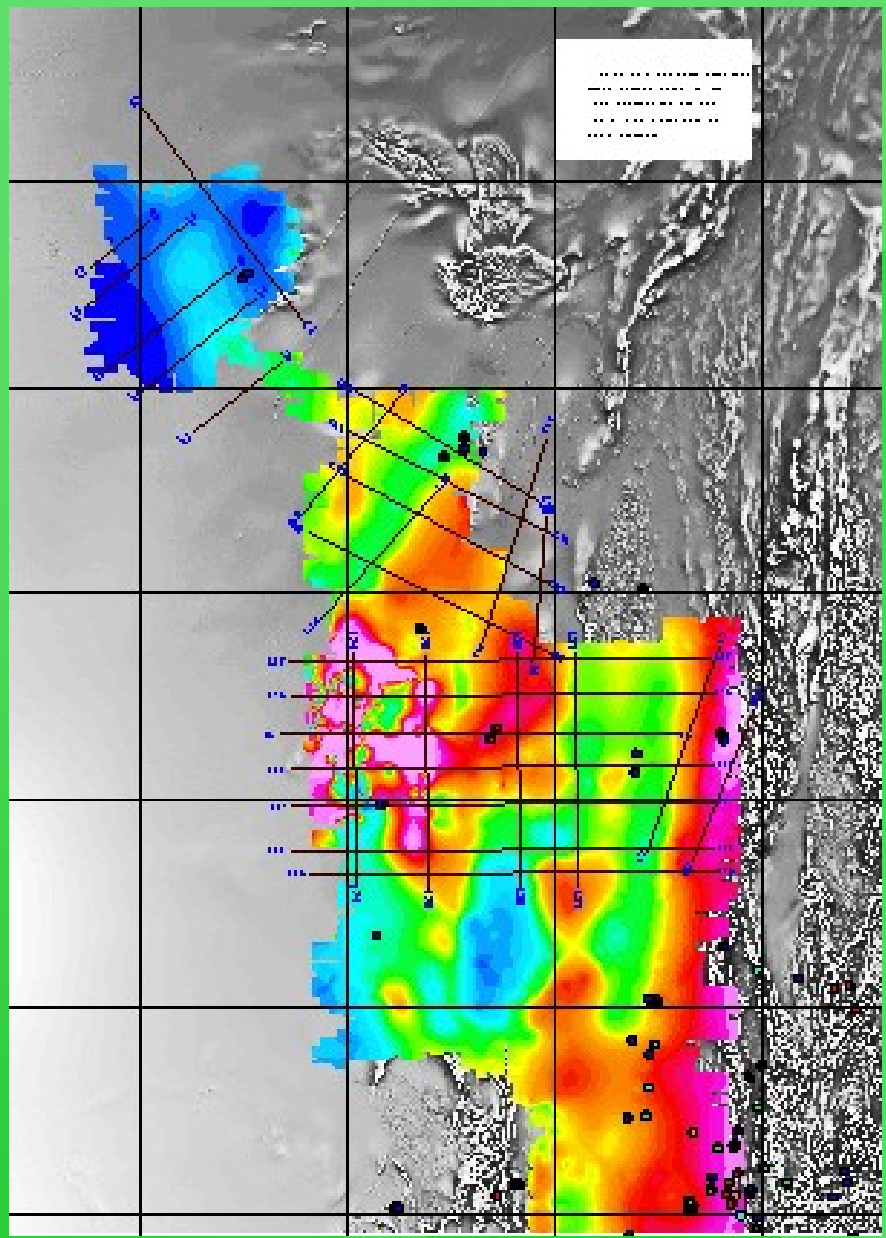
Limitations:

- **Incomplete potential field data coverage, especially gravity**
- **Incomplete rock properties database**



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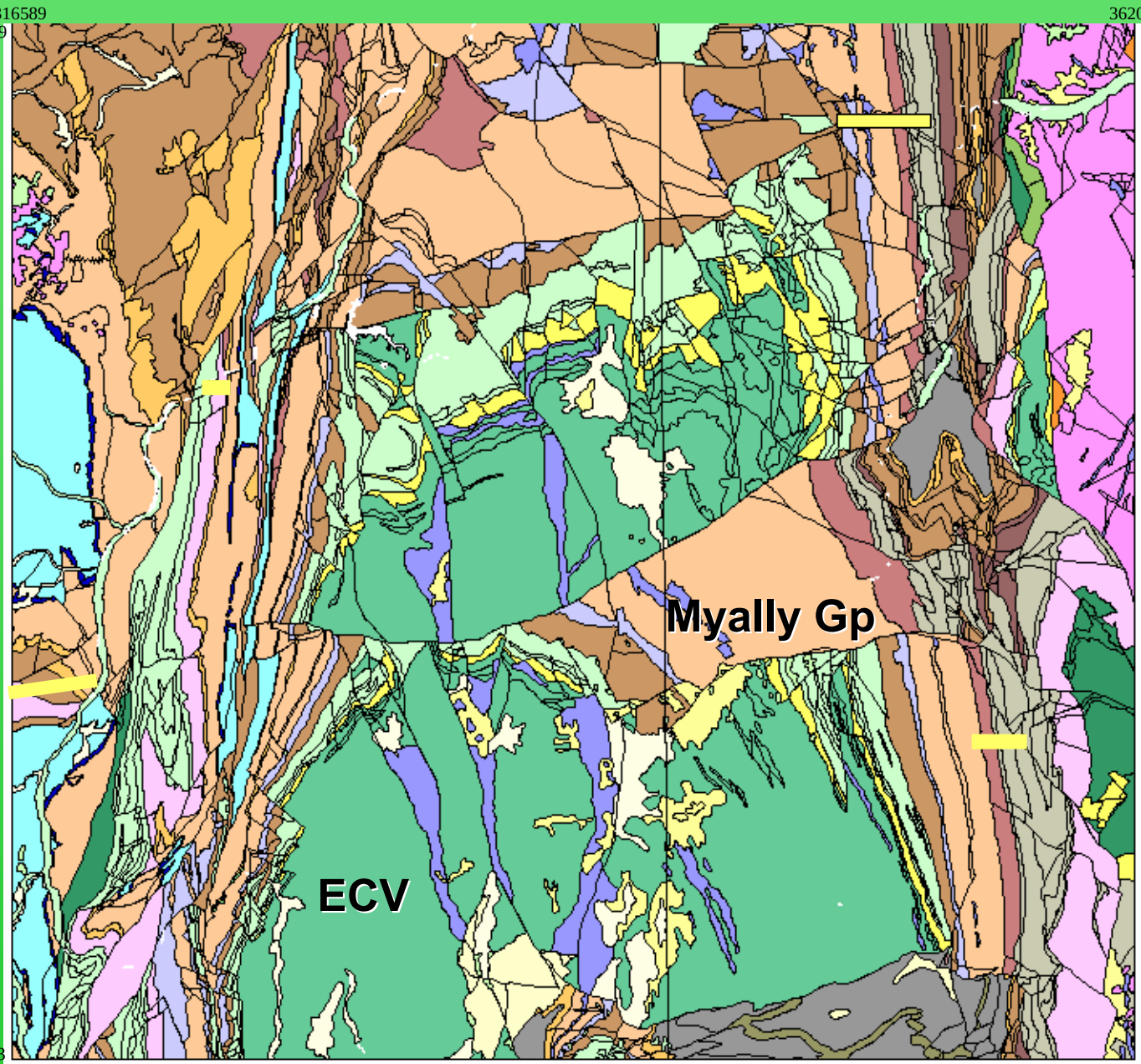
3D Geometry Key Features

- South-dipping E-W trending faults
- N-S corridors of higher strain
- North tilted fault blocks
- Higher stratigraphic levels in north



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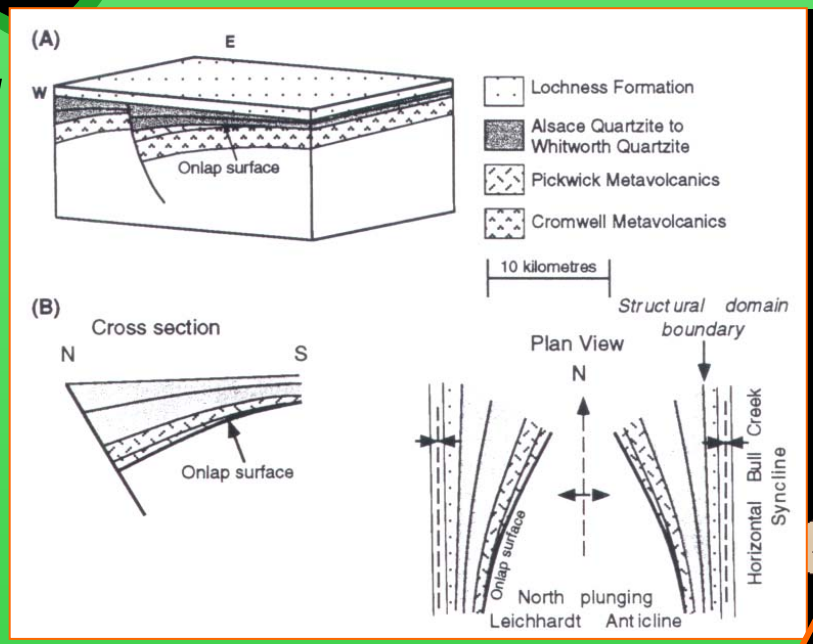

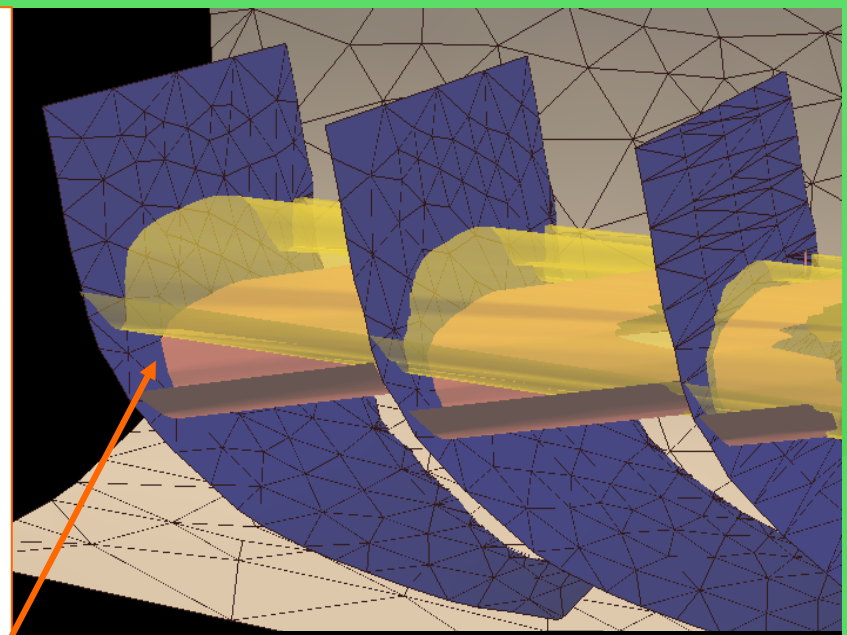

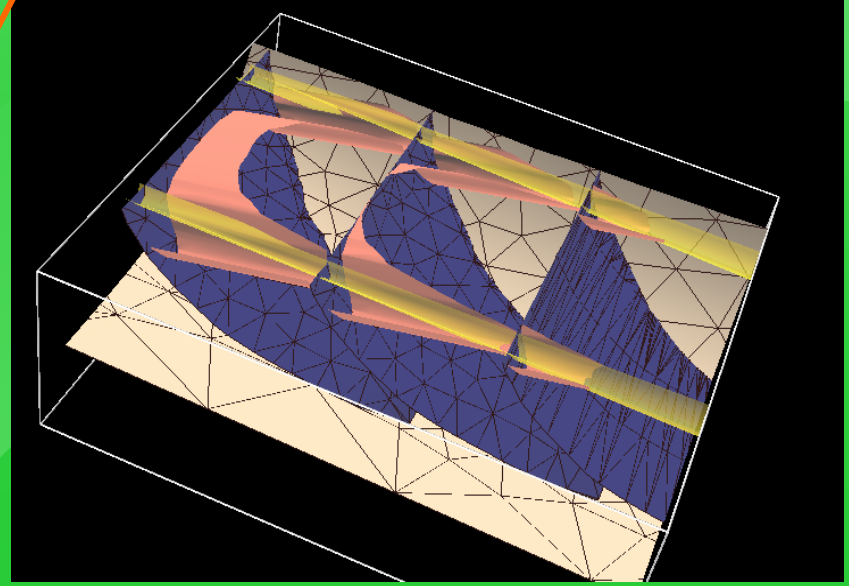

Yellow = Base of Loch Ness Fm.

Pink = Top of ECV

Blue = growth fault

(after O'Dea 1997)

Whitworth & Alsace qzites

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Bull Creek

Boozers Waterhole West

Crystal Creek

Quilalar (lower)

Lochness Formation

500m

Whitworth Quartzite

Bortala Formation

Alsace Quartzite

Investigator Fault

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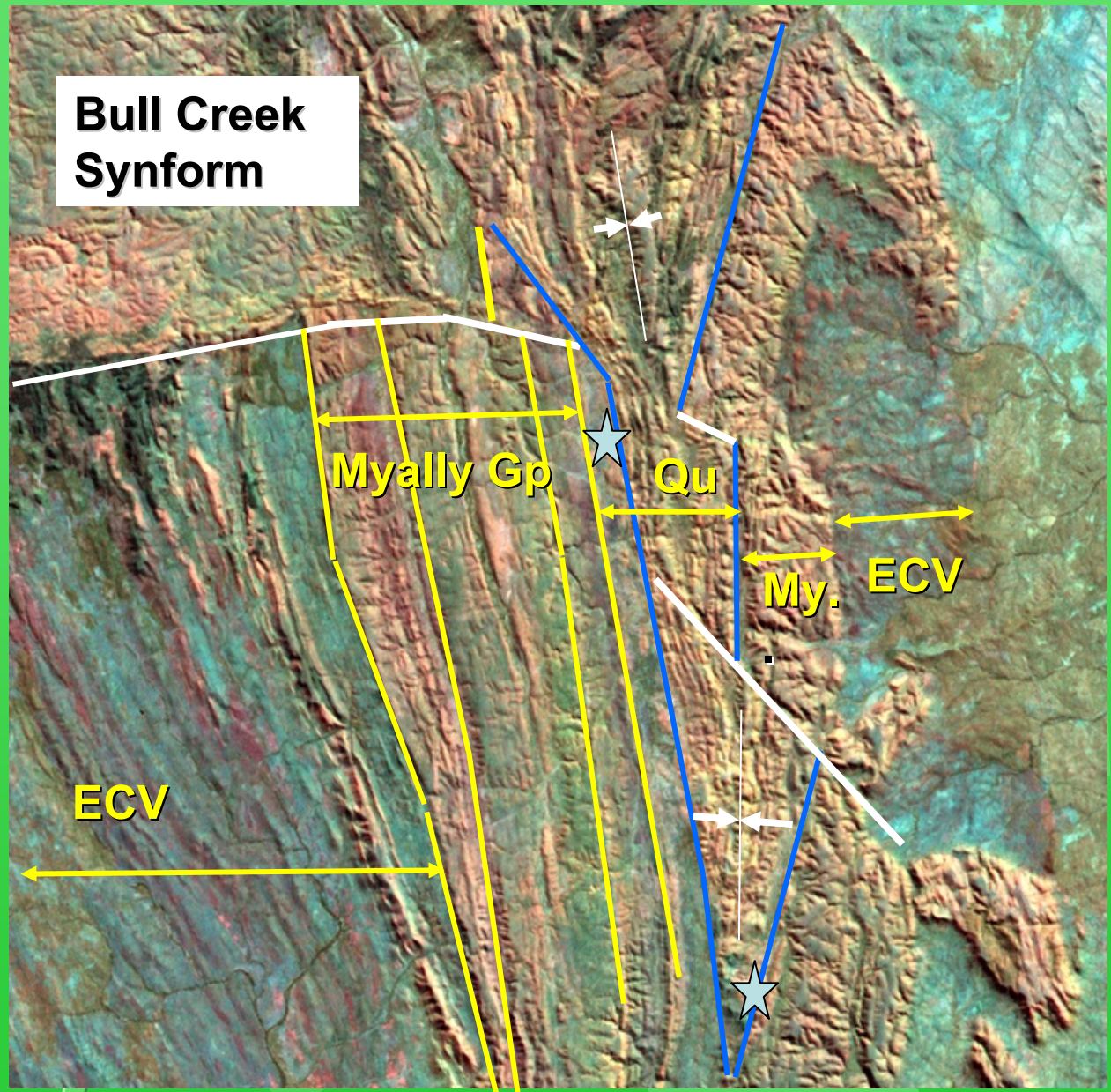
- Not simple wedge geometry
- E-W shears post-date Myally Gp?
- Loss of stratigraphy across synform→erosion or tectonic excision
- Truncation in upper Quilalar Fm→Unrecognised U/C or structure



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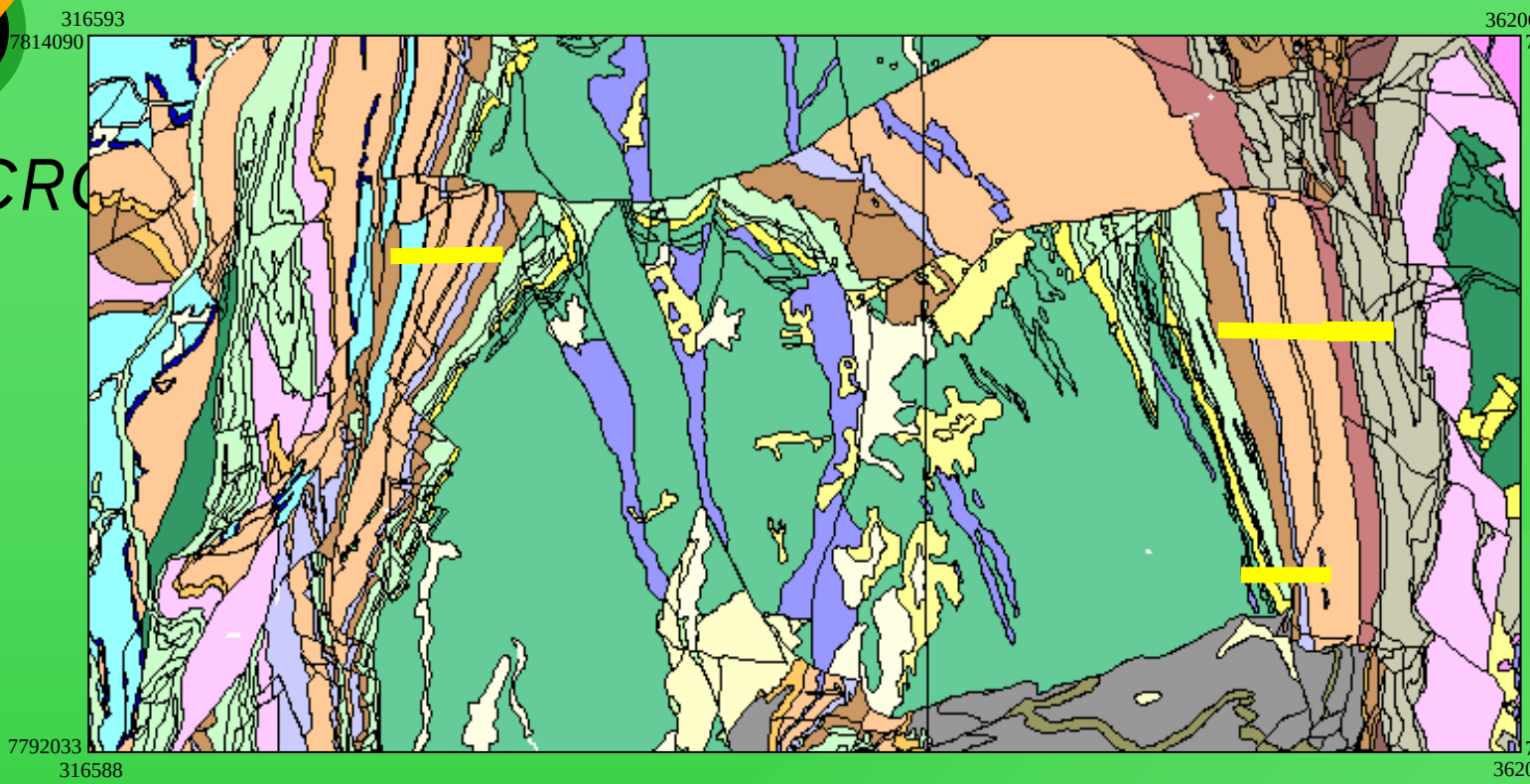

- No mirror image across north-plunging antiforms
- Asymmetry in opposing preserved sedimentary wedges: no Loch Ness (red) or Quilalar Fm (grey) in west
- Loss of stratigraphy – erosion or tectonic excision?

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Timing of Mineralisation vs Deformation

- Basal upper Quilalar Fm = Fe-Mn gossans
- Regionally developed K- feldspar-hematite (magnetite)- quartz alteration
  - Occurs as en echelon veins in cleaved rocks
  - Siltstone/shale hosted
  - Syn- to late D1 in age (syn- to late D1 slaty cleavage → North to South basin inversion?)
  - Occurs at all stratigraphic levels (Bortala; Loch Ness; upper Quilalar Fm)

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Mineralisation styles

Potassic vein alteration in lower Quilalar Fm: Bull Creek Syncline

K-Feldspar-Hematite-quartz veining in cleaved Bortala Fm: Esperanza Waters

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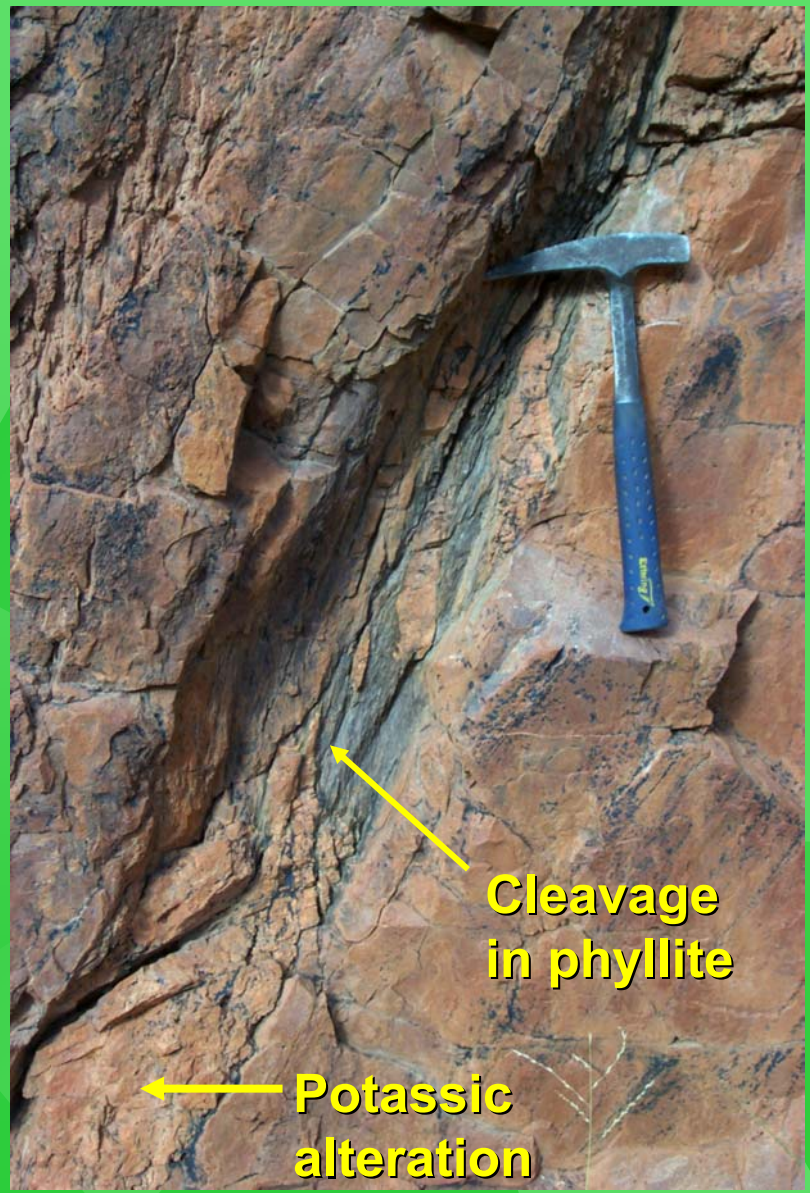

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Geochronology

- Zircon geochronology
  - Chronostratigraphy (Max. depositional age)
  - Provenance
  - Delineate structural repetition/excision
- Ar-Ar dating
  - Linkage to H4 (University of Melbourne)
  - Deformational fabrics
  - K feldspar alteration
  - Time of fluid migration

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Constraints on Tectonic History

- Thermobarometry (illite crystallinity + white mica b^0 cell dimensions)
- Collaborative project (University of Newcastle)
- > 100 samples collected to determine:
  - Burial & thermal maturation history of sediments
  - Indentification of missing stratigraphy (erosion vs non-deposition)
  - Resolution of extensional vs contractional shear zones & juxtaposition of variably buried units
  - Regional trends & variation in metamorphic grade

Enabling technologies: marrying PIMA with hyperspectral analysis

- Differentiation of lithological units through mineralogical content (clays, micas, chlorites)
- Mapping of hydrothermal alteration patterns (fluid conduits)
- Identification of major stratigraphic/structural breaks
- Regional and mine scale changes in mineralogy
- Pilot studies: Termite Ra. Fault & Bull Creek syncline (Eastern Creek Volcanics versus overlying sedimentary rocks)
- Employing Landsat (Band 157 RGB) & Hyperion

PIMA : SWIR - analysis

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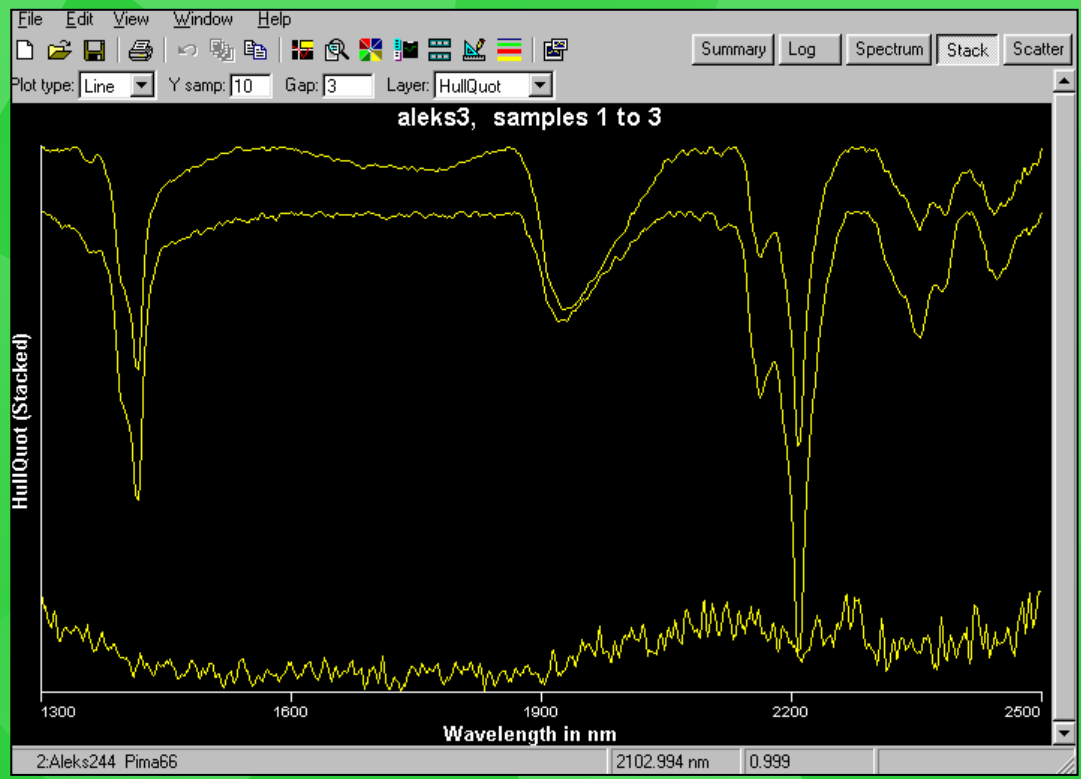
- Pima analysis of fresh (top) and weathered rind (middle) of coarse grained sandstone (Warrina Park Quartzite). Phengite and kaolinite identified.
- Bottom: trace from fine grained shale (Surprise Creek Formation). No spectrally active minerals = noisy, flat spectrum.



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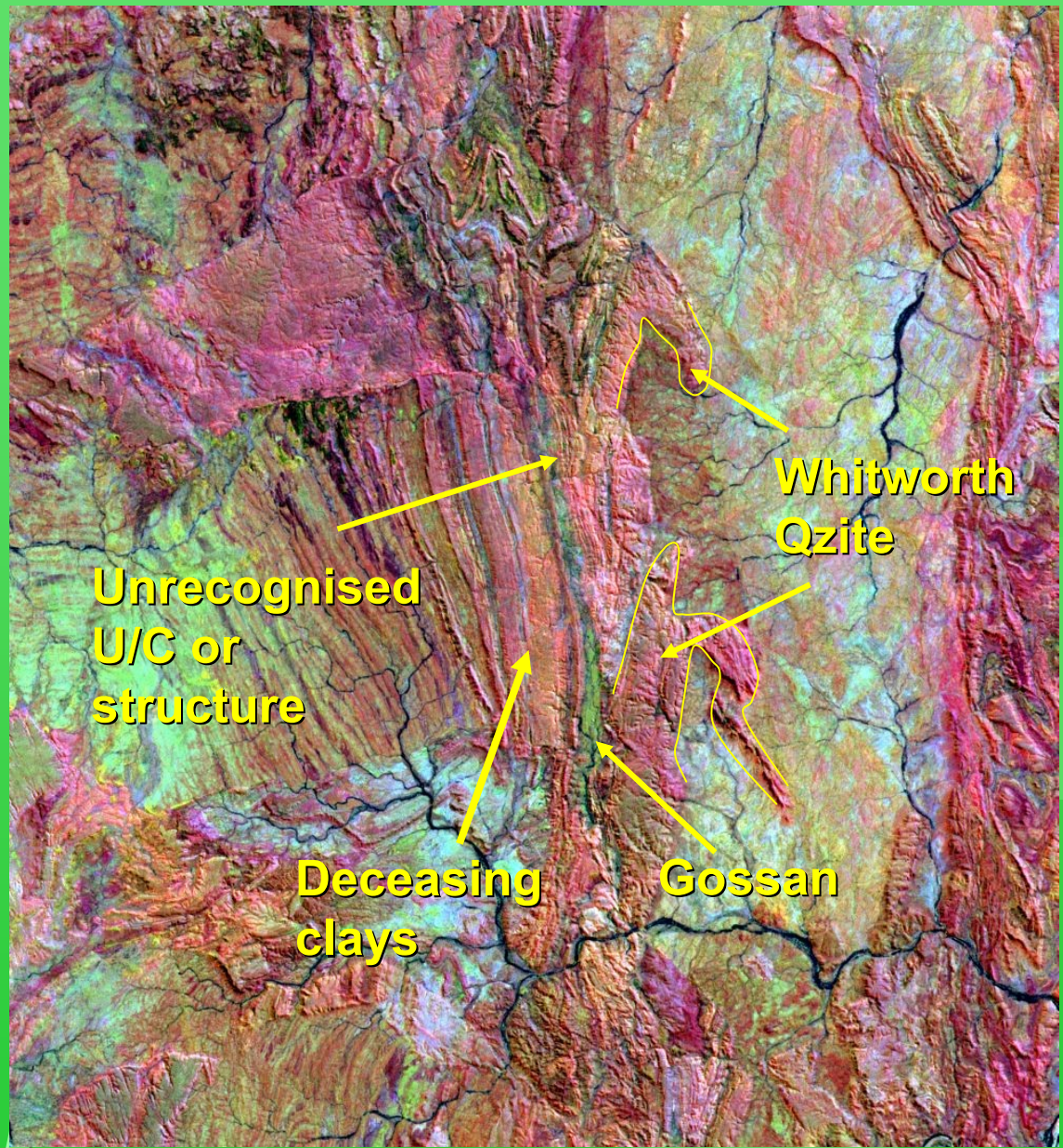
Landsat image processed to enhance resolution of clay (red), iron oxide (green) and silica-rich (blue) units

- Separates different sandstones & siltstones
- Lithological repetition



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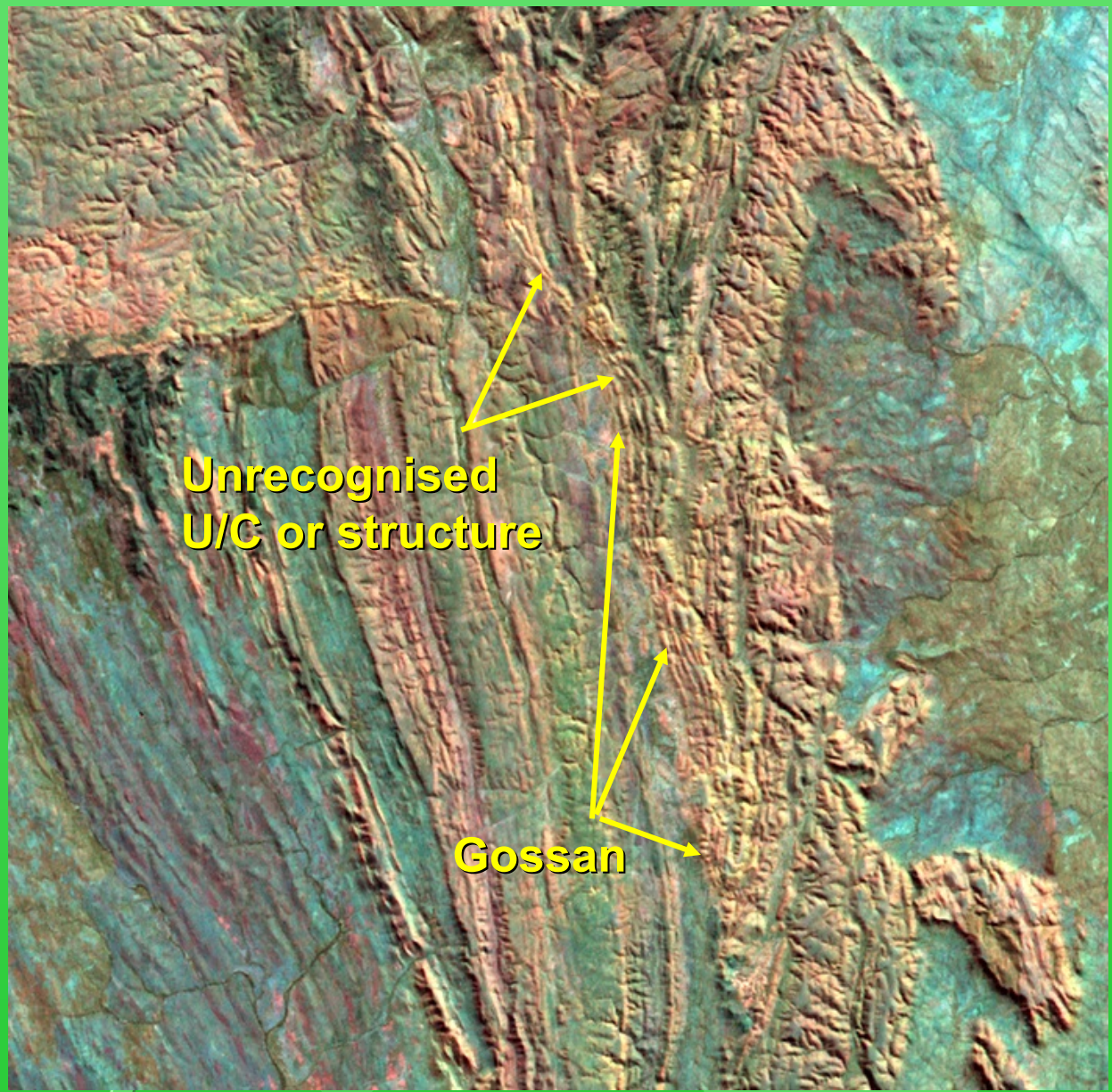
Key result:
Alteration & fluid flow controlled by unrecognised discontinuity in Quilalar Formation

Landsat Band 157; red (clays); green (Fe); blue (SiO2)



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Geochemical Signatures

- Preliminary geochemical contour maps using Petrosys
- Indentification of metalliferously fertile units
- Assessment of structural versus stratigraphic control on mineralisation
- Gridded and contoured maps of alteration index and metal index* (sample area 139° - 140°E, 19° - 21°S) :

  $AI = (FeO + 10MnO) \times 100 / (FeO + 10MnO + MgO)$

  $MI = Zn + 100 \times Pb + 100 \times Tl$

* Based on Large & McGoldrick (1998): Lithogeochemical halos and geochemical vectors to stratiform sediment hosted Zn-Pb-Ag deposits, 1.Lady Loretta Deposit, Queensland. Journal of Geochemical Exploration, 63, 37-56.

Geochemistry

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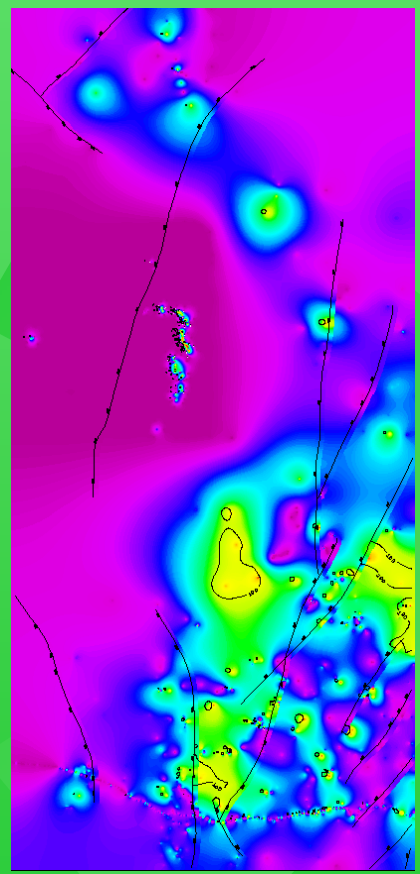
Geology (1:2.5M)
● Pb-Zn deposits

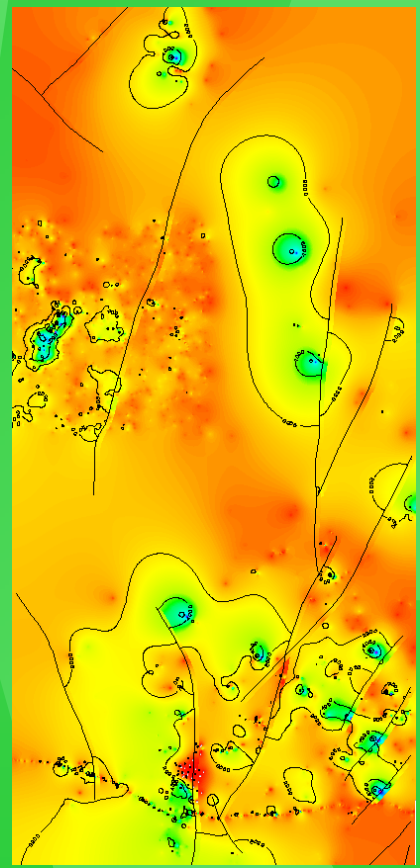
139°00 140°00



Alteration index
High Mid Low

139°00 140°00

19°00



21°00

Metal index
High Mid Low

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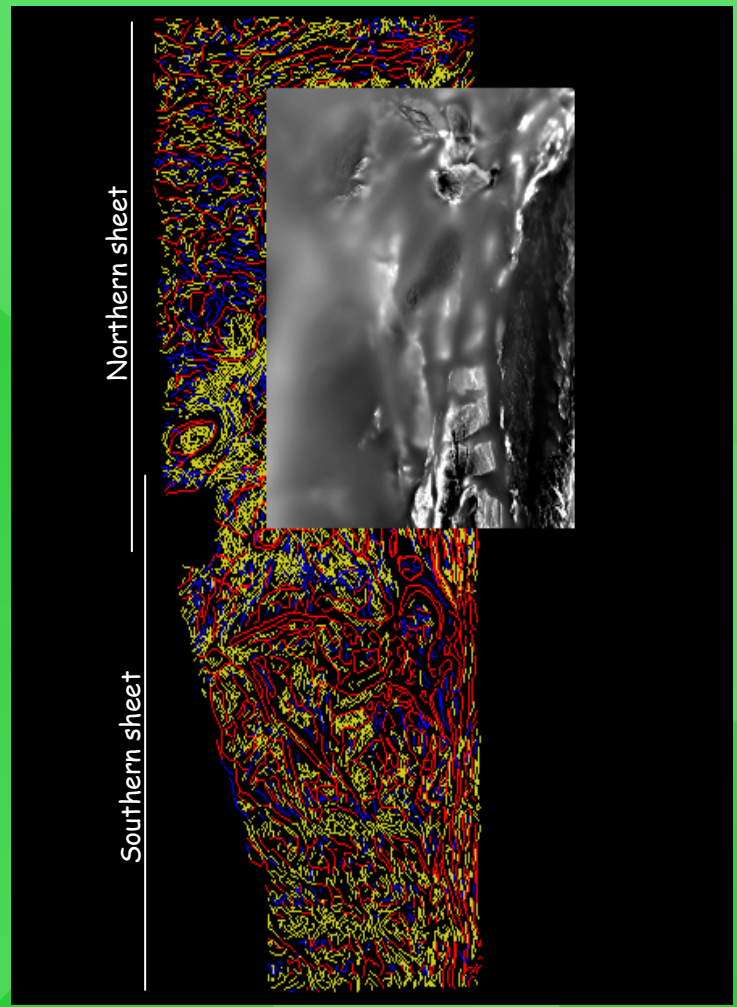
Delineation of fluid conduits through frac-worming

Only recognise worms that have surface expression

- **Potential field data for different levels statistically analysed**
- **Isolated domains analysed independently**
- **Vector analysis of worms (“lineaments”)**
- **Comparison with other data sets (TMI)**

The red lines represent 5000m upward continuation (the ‘deepest’ structures); blue lines 2000m; yellow lines 1000m



Screen capture from Gocad displaying the extent of worm interpretation vectors. Total magnetic intensity (TMI) image of the I1 3D model area

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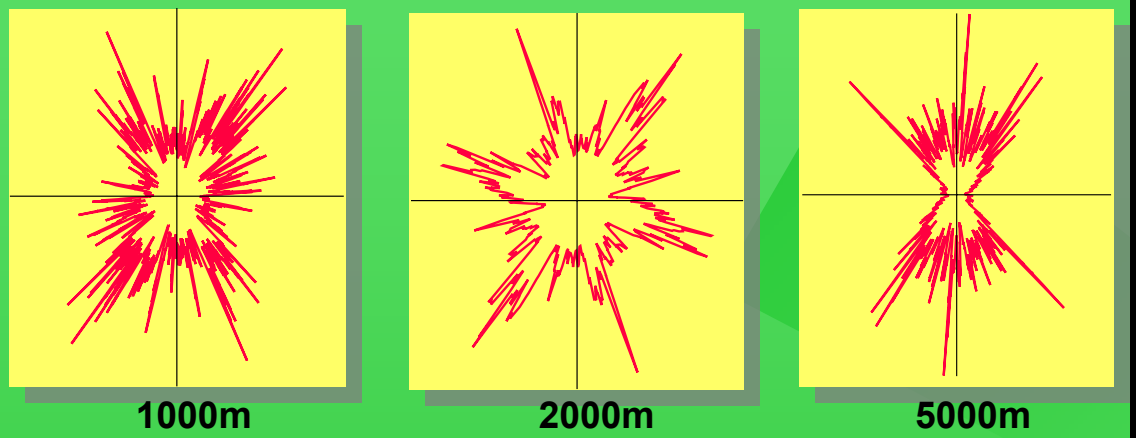
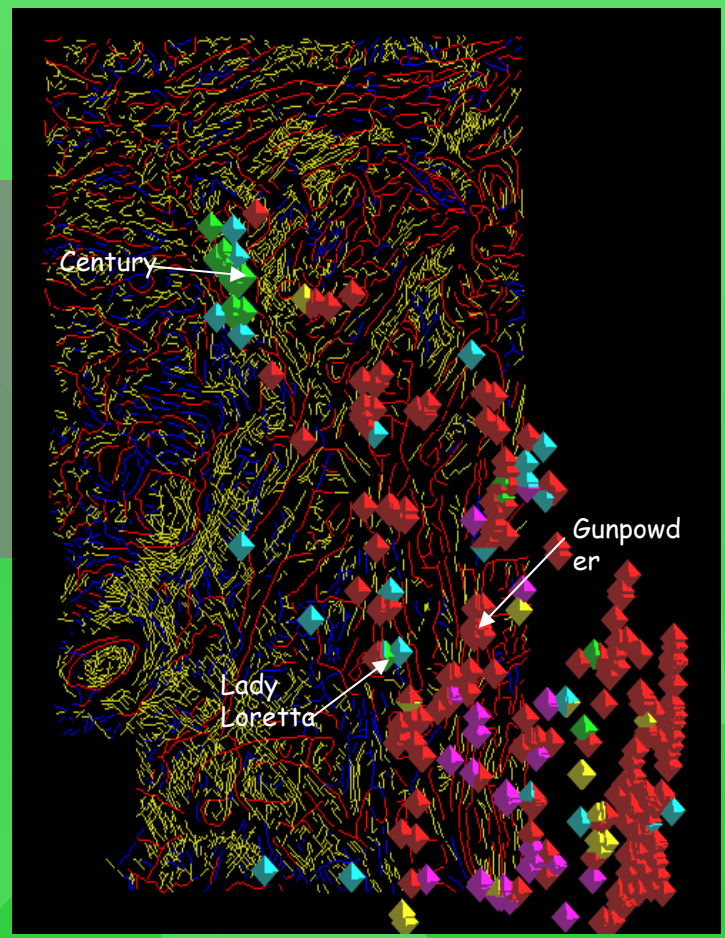
Northern sheet



- **Century mine on NW lineament (Termite Ra. Fault)**
- **NE lineament ~ Mt Gordon Fault trend**



Northern sheet

Screen capture from Gocad, displaying mineral occurrences overlain on worm interpretation lines. Red lines represent 5000m upward continued worms projected to surface; Blue lines 2000m; Yellow lines 1000m. Green diamonds Pb/Zn; Yellow diamonds Au; Red diamonds Cu; Purple diamonds Uranium

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Statistical Analysis of Worms

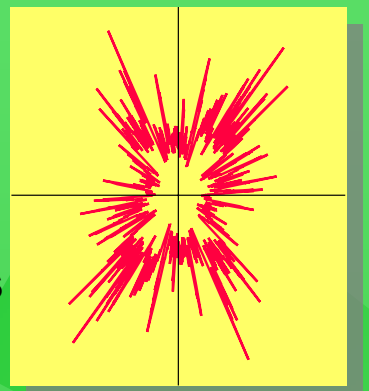
- Assume upwardly continuous wavelets correspond to 'increased depth'

- Data digitised data to produce series of vector lines

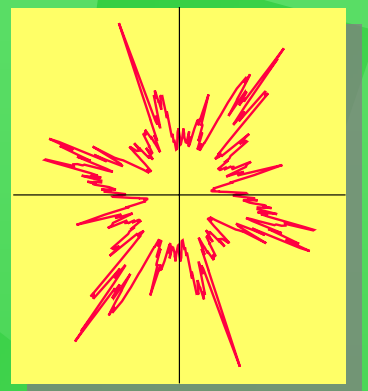
- Statistical analysis of vectors

- Structural trend lines

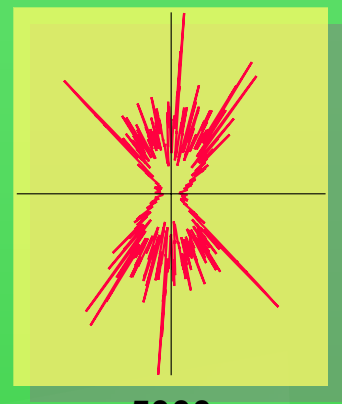
Northern sheet



1000m

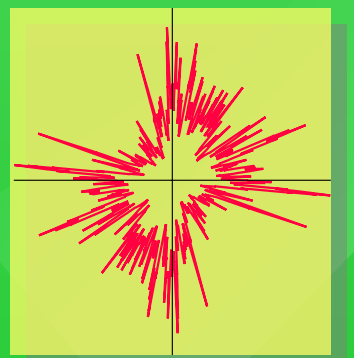


2000m

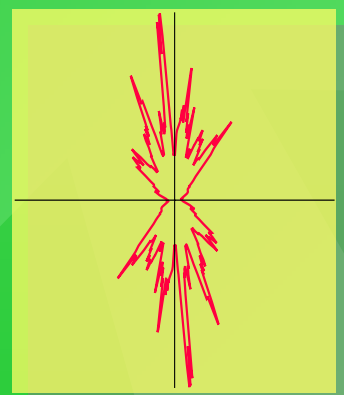


5000m

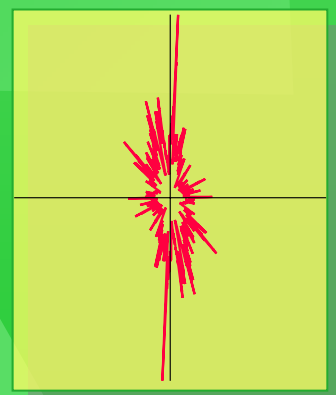
Southern sheet



1000m



2000m



5000m

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Simple isn't it!

- Simplified geology
- Sequence boundaries
- Marker horizons (e.g. Mount Oxide Chert, Torpedo Creek Quartzite)
- Regional structures